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The Glands of Internal Secretion and Metabolic Processes

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THE glands of internal secretion have a regulating influence upon the growth, nutrition and development of the body. The mechanism by which these metabolic processes are regulated has been the object of long lines of investigation. Valuable information has been accumulating during the past fifty years. Tremendous advances have been made in the past fifteen.

Sifting out the inaccuracies of popular conception we have a few facts that have been clearly demonstrated with reference to some of the following glands: thyroid, parathyroid, suprarenal, pituitary, islands of Langerhans, thymus, pineal body and sex glands (ovaries and testes). Certain other organs, namely, liver, spleen, kidneys, appear to have in addition to their well-recognized functions the power of modifying some phases of metabolic processes. Each gland has its own type of cell which is capable of producing its own specific secretion. This substance, spoken of as a hormone, is carried into the body tissues by the circulating blood. Each substance is capable of affecting the physiologic activity of distant tissues in its own peculiar way. Disease of a gland may increase or decrease the quantity of this hormone, or may change its character so that its effects may differ from the normal. In a few instances a lack of specific hormone may be corrected by supplying some from an external source; an overproduction of specific hormone in some instances may be corrected by removing surgically some of the overactive gland.

Each of these glands has a large blood supply through a network of blood vessels. A modification of this blood supply or of the number of cells in the gland or of the character of the cells in the gland will change correspondingly the character or quantity of its peculiar secretion. The blood supply may be interfered with by a clot or an embolus or inflammation, or by a tumor pressing upon blood vessels or gland tissue, or by germs carried to the gland where they start to grow. Or, the damage may come from toxic substances that are carried there from a distant point. Such damage results in at least altering the capacity of the gland to produce its normal secretion. The alteration may be temporary or permanent; it may be infinitesimal or perceptible in amount. The altered hormone modifies the normal rate of growth or development of body tissues

and thus alters the capacity of the tissues to use oxygen and food and to produce carbon dioxide and other wastes—to metabolize.

Some of these variations in metabolism are susceptible of measurement and so lend themselves to interpretation. One of the metabolic tests is known as the basal metabolic rate. As carried out clinically, this is a breathing test to determine the rate at which the body as a whole consumes oxygen and produces carbon dioxide. It is measured when the body is at rest, when the temperature is normal, when physical and mental activity are at a minimum and when digestive processes and their stimulative effects are at the lowest level. Measurement is expressed as calories of heat produced by the body per square meter of body surface per hour. An oversupply of thyroid secretion definitely raises the rate above normal; a shortage lowers it below normal. Other hormones influence the metabolic rate in one way or another; some in a way that can be interpreted and others not, at the present time. The varied interplay of hormones upon tissue adds enormously to the difficulties of interpretation.

One very fruitful method of studying the functions of any organ, and particularly of the organs of internal secretion, is to observe a patient with an abnormality of that organ, study the symptoms, and then ask why these symptoms occur.

An exophthalmic or toxic goiter presents itself with over-irritability, palpitation of the heart, sleeplessness, fine tremor of extended fingers and tongue, loss of weight, excessive appetite, easy fatigue, excessive perspiration, sometimes a prominence of one or both eyes, with or without a prominence of the thyroid gland, and an increased metabolic rate—10 to 100 per cent above normal. The increased or modified secretion of the thyroid gland has keyed up to a higher level the speed of the engine. All cells burn fuel, use oxygen, and produce carbon dioxide at an increased rate. A more rapid blood flow is required to convey these to and from the distant tissues. The heart rate increases in an attempt to meet this need. More fuel as food must be furnished, so appetite is increased; but often not sufficient food can be taken to balance against the excessive consumption, so body tissues are called upon to furnish the deficit. Excessive intake of food often irritates the gastro-intestinal tract and diarrhea results. The tremor is partly, at least, a result jointly of the increased cellular metabolism of nerve and muscle, the usual nice balance between sensory reception and motor response being disturbed. The prominence of the eyes is not completely explained, though it is brought about in part by a widening of the distance between the eyelids probably through irritation of the sympathetic nerves supplying Mueller's muscles which are attached to the lid cartilages.

The above train of symptoms may be set going in a normal individual by the administration of dried thyroid gland or of thyroxin (a chemical isolated from the thyroid gland by Kendall of Minnesota) in appropriate doses. The same drug in appropriate doses administered to a patient with dry hair, thick skin, lethargic disposition, slow pulse, diminished perspiration and a lowered basal metabolic rate, that is, a patient with myxedema, will cause the symptoms to disappear and the rate to rise to normal. Thus this condition, also known as hypothyroidism, may be corrected. If the dose to this individual is pushed up, hyperthyroid symptoms described above may supervene.

Symptoms of hyperthyroidism are often greatly magnified, whether the attack has an acute or a gradual onset, by the toxic material from some focus of infection, as tonsils, teeth, appendix, gall bladder, sinuses, or the like. These should be cared for where possible. It is customary among many and it is good practice always to put such a patient to bed to decrease the excessive demand of the active muscles and nerves and to slow the heart and reduce mental activity and anxiety. The ice bag over the heart is said to slow its rate. Iodine is often used at this stage to further lower the metabolic activity. The mechanism by which it accomplishes this is not known. The surgical risk of patients in high grade hyperthyroidism is notably high. The risk is reduced appreciably by a lowering of the metabolic rate accomplished through bed rest, sedatives, iodine and adequate food. When surgery is the next step, either the thyroid arteries may be tied off, thus reducing the blood supply to and therefore the secretory rate of the gland, or part of the thyroid gland may be removed, leaving only an amount sufficient to furnish the normal quantity of secretion. X-rays and radium are applied to the overactive thyroid, but their use has been over too brief a period of time and is not susceptible of sufficiently accurate control to justify them at the present time as conservative procedures.

The adolescent goiter which is far more common in girls than in boys, occurs at the time of life that its name indicates. It is found especially in the so-called goitrous districts which comprise the country surrounding large inland fresh-water lakes. The condition frequently subsides spontaneously, but it does often seem to serve as a basis for future thyroid enlargement. Such an enlargement may become a toxic or hyper-thyroid in the twenties or thirties, a non-toxic adenoma in the thirties or forties which may become toxic later, a large unsightly colloid goiter in the forties or fifties. The last may degenerate into a cystic goiter, and a diminution of normal secreting gland tissue result in a hypothyroidism. The infant born with a deficiency of thyroid tissue, known as a cretin, is mentally slow, has thick skin, coarse hair, coarse typical facial features, chubby extremities, is clumsy and fat. The condition may be improved for a time by the feeding of dried thyroid or thyroxin. Death usually takes such children before they get far into the teens, because of their susceptibility to respiratory infections.

The parathyroid glands are several small masses of tissue on either side of the thyroid gland. Care is exercised now in surgery to avoid the removal of these when the thyroid is removed. Deficiency or lowered activity of this glandular tissue occurring in infancy gives symptoms of so-called spasmophylia. There is an over-irritability, twitchings of the muscles of the extremities, and pains, occasional convulsions, contractions of hands and feet in carpo-pedal spasm. These symptoms are associated with a marked lowering of the calcium content of the blood and a diminished output of phosphates in the urine. A similar picture may arise later in life when damage comes to the glands through inflammation, tumor, disease or surgical removal. Death results from exhaustion unless the calcium content of the blood is raised to the normal level. This may be accomplished by the use of calcium compounds by mouth or intravenously or by the use of parathyroid extract hypodermically. This material was isolated by Collip of Canada and is one

of the most recent marked advances in the field of the endocrines.

The suprarenal glands are cap-like structures fitting over the upper pole of each kidney. They contain two types of tissue. The outer layer is known as cortex, whose function has not been defined beyond a general relationship to sexual development and the probable production of a chemical which lowers blood pressure. The inner portion, known as medulla, has much the appearance of certain yellowish colored centers of the sympathetic nervous system. It plays an important part in the control of blood pressure, of the state of tone of the blood vessels and of pigment formation of the skin. As is true with other ductless organs, there may be an overfunctioning or under-functioning of this tissue. The disease most commonly seen in which these glands are damaged is known as Addison's disease. Symptoms consist of progressive general languor and weakness, enfeebled heart action and lowered blood pressure, gastro-intestinal irritability and a bronzing pigmentation of the skin. The cause of these symptoms and their invariable advance to death is not understood. Some relationship does exist, however. An extract of the gland, made first by Abel of Johns Hopkins, and now used clinically throughout the medical world as adrenalin or suprarenin, or some name of similar significance, causes the muscles of the blood vessels to contract, muscles of the bronchi to relax, blood pressure to rise and sugar in the liver and tissues to be made available at once for fuel. The administration of adrenalin, however, does not cure Addison's disease nor does it relieve its symptoms. The damage to the suprarenals in this disease is due almost always to a localized tuberculosis from a focus in another organ. Again, circulatory failure, inflammation or tumor may be responsible for the damage.

The pituitary body or hypophysis is a pea-sized organ lying back of the bridge of the nose in front of a line connecting the ears, appearing as an extension of the brain into a bony pocket known as the sella turcica. It is made up of three parts which seem to possess different functions. In general it has to do with the control of the growth of bone and muscle and the burning or storing of carbohydrates and fats. The period in life during which damage is done to the hypophysis, whether before or after maturity, regulates the variation in symptoms that results. Over-activity of the gland, when occurring early in life, may lead to gigantism or a generally overgrown, tall individual; when occurring after maturity, to acromegaly with thickening and prominence of facial features, especially maxillary bones and nostrils, enlargement of skull, enlargement of hands and feet, and symptoms due to pressure upon neighboring structures, such as eyes and brain. When there is an underproduction of hormone beginning in childhood the symptoms include adiposity, infantile bony features and lack of sexual development; when the onset is in adolescence or later the result is adiposity and recession of sexual characteristics. Either of these conditions may be and usually is associated with evidence of failure or excessive function of one or more other glands of internal secretion. Evidences of hyper-activity may be followed later by evidences of hypo-activity. A common symptom in adults is an increased tolerance for sugar and an unusually large output of urine, a condition known as diabetes insipidus. The administration of extracts of different parts of the gland

seems not to modify the course of the disease. Pituitary extract which comes under several different trade names, is used clinically to cause contraction of smooth muscles such as uterine and intestinal muscle. It is used to some extent in deficiencies of the pituitary gland.

A group of minute cells lying between the glandular elements of the pancreas, known as the islands of Langerhans, have to do with the burning of glucose as fuel by the body. How it is accomplished we do not know, but material was extracted from these cells by Banting and Best of Toronto and it is marketed now under the name of insulin. This material, thought by some to be the hormone of the islands, is used in diabetes mellitus to supplement the power of the body to use glucose as fuel. Food taken into the body furnishes energy by being burned either in the form of glucose or fatty acid, or it is stored as carbohydrate, protein or fat. In this disease, when glucose fails to burn in sufficient quantity, that which fails to burn is treated as a foreign body and is excreted by the kidneys. This sugar, in order to be excreted, must be dissolved in water, so increased amounts of water are drunk and increased amounts of urine are passed. To meet the fuel deficiency, more food must be consumed, and thus we account for the increased appetite, also for the loss of weight and strength when the demand for more food is not met entirely. When the water deficiency is not met by increased intake, the tissues become dry, and often the vision is disturbed by this effect on the media of the eye.

When the glucose and fatty acids burn normally in the body, they burn economically and in a definite proportion one to the other. The development of an inability to burn glucose in a normal amount disturbs that proportion. The body continues to demand just as much heat to maintain a temperature of 98.6 degrees and life, so when less glucose burns more fatty acids must burn. But the fatty acids, without the proper proportion of glucose, burn only incompletely, and these partially consumed products of fatty acid combustion which are acid in nature must be excreted largely by the kidneys. The body attempts to neutralize these acid substances with alkali normally present in the body and the result is a depletion of the alkali reserve of the body. By these steps the failure of the body to burn the requisite amount of glucose may and often does result in so-called acidosis with the added symptoms of very dry tissues, odor of acetone to the breath, deep respirations, drowsiness, flushed cheeks and coma. The increased respiration is demanded in part to help carry off the incompletely burned fatty acids and in part to carry off the carbon dioxide which the blood cannot carry as rapidly when the alkali store is depleted.

The correction of this long series of errors must start at the beginning. Glucose must be made to burn. Insulin can empower the body to do this. Fortunately the train of events can be interrupted, often before they have progressed far, and adjusting the food intake to just meet the fuel requirements brings the glucose down to an amount which the body can burn. Then insulin, the hormone, is unnecessary. In any case, with or without insulin as a help, the food must be carefully weighed in order to ensure the eating of an adequate and only adequate amount in proportions that will burn economically and include no more glucose-forming food than can be burned by the body.

The thymus is a thin flat gland

lying beneath the sternum. It is sometimes found enlarged in infancy and childhood, or may be persistent in maturity instead of diminishing in size at that time as is normal. Symptoms of enlargement or persistence are chiefly from pressure upon nearby structures. The function is not known, but it is assumed to be related to the lymphoid tissues because in death from status lymphaticus there is often marked thymus enlargement, also there is associated with enlarged thymus abnormalities of secondary sexual characteristics.

The pineal body is a small gland enclosed by brain tissue, whose hormone is not known and whose function is vaguely guessed at. Disease of the gland results largely in pressure on surrounding tissue, but there is associated often an early puberty, an increased tolerance to glucose, obesity and increased growth of hair.

The sex glands have directly to do with primary and secondary sexual characteristics. Removal of these modifies the characteristics. The hormones of the ovary, corpus luteum and testis are not known. Their effect is known only through removal of the glands. Replacement by giving dried gland by mouth, by extract hypodermically, by transplantation from another individual, is entirely ineffective by the methods in use up to the present.

Liver, spleen, kidneys, placenta, secretory glands of the duodenum and other organs have numerous well-defined and some poorly understood functions. There is much evidence that indicates inter-relationship among certain of them. Some of the evidence points to the presence of hormones that regulate these inter-relationships. All we know of them is by their effects. What they are or how they operate is still in the realm of the unknown.

Progress in the study of the glands of internal secretions has been made through painstaking studies of the body and cellular metabolism, of diseases of the glands and of the pharmacologic effects of extracts of the glands.

The contributors to the general field have numbered more than to perhaps any other field. Charlatanry is encouraged in any field that is full of unexplored paths. To offset this, encouragement should be offered those who are gifted to explore the paths and to make known the truth, so that only the known and tested methods will be relied upon by intelligent people.

Nursing in Endocrine Disturbances

By Gunda Engen, R.N.

WHILE "endocrine disturbances" cover many diseases, essentially different and still fundamentally the same or closely related, the nursing care of all of these should require first, of course, a thorough knowledge of these glands and the important rôle they play in the growth and metabolism of the body.

Many of these diseases do not need such nursing care as actual bedside nursing would cover, yet they do require nursing. These patients need watching, encouragement and help, probably more than any other type